

SOIL AND GROUND WATER ASSESSMENT REPORT

BOEING EMP

For

**Perkins, Coie, Stone, Olsen & Williams
Seattle, Washington**

By

**Landau Associates, Inc.
Edmonds, Washington**

11 April 1986

SCL 05922

CTY0050825

SEA291282

EXECUTIVE SUMMARY
SOIL AND GROUND WATER ASSESSMENT REPORT
BOEING EMF

PURPOSE OF REPORT

To report the initial results of an investigation to characterize ground water and soil contamination near The Boeing Company's Electronic Manufacturing Facility (EMF) in south Seattle, Washington.

STUDY OBJECTIVES

This investigation was conducted by The Boeing Aerospace Company in response to a Washington State Department of Ecology (WDOE) order which established the study objectives summarized below:

1. Identify the characteristics of ground water and the general hydrogeology of the EMF site to define all potential migration pathways of contaminants in the ground water and to select remedial alternatives.
2. Identify the presence, locations, quantities, concentrations, and sources of hexavalent chromium, trichloroethylene, and other contaminants in the ground water.
3. Describe onsite and offsite ground water uses and use rates.

FIELD PROGRAM

Eight new monitoring wells were installed at six locations at EMF as part of this investigation. Soil samples were obtained during the drilling of the new monitoring wells in order to determine

the stratigraphy of underlying soil, and the nature of the ground water regime. Ground water samples from eight new monitoring wells and the pre-existing well points were chemically tested to characterize ground water quality at EMF and to analyze the nature, extent, and mobility of contaminants in ground water. Water level measurements were conducted to determine ground water gradients and correlations with tidal fluctuations in the Duwamish Waterway. Permeability tests were conducted at all new monitoring wells to determine soil permeabilities and preferred pathways for ground water movement.

FINDINGS AND CONCLUSIONS

Results of field investigations and contaminant transport analyses indicated the following findings and conclusions:

1. There are no registered ground water production wells within a 3-mile radius of EMF; therefore, the Duwamish Waterway was established as the primary receptor of concern.
2. The location of the buried Duwamish River channel near the EMF site could not be determined with certainty.
3. Except for concentrations of trichloroethylene in well points WP 9 and 9A (inside the EMF building), all levels of organics in the ground water were below Freshwater Aquatic Life Criteria.
4. Concentrations of hexavalent chromium were at or below detection limits in all monitoring wells and well points. This is due primarily to the chemical reduction of hexavalent chromium to trivalent chromium within the natural soil environment.

SCL 05924

5. Elevated concentrations of trivalent chromium, copper, lead, and zinc were found in well points within the EMF building. The elevated concentrations may be attributed in part to the plating operations and the use of galvanized steel pipes as casing for the well points. The metal exceeding criteria by the highest ratio was copper, with a maximum concentration of 10,000 ppb in WP 9.
6. Conservative assumptions were made in calculating mass movement rates for trichloroethylene and copper from EMF to the Duwamish Waterway. Based on these calculations, maximum concentrations of trichloroethylene and copper in the Duwamish Waterway were determined to be 0.012 ppb and 0.0012 ppb, respectively. These calculated concentrations are well below chronic exposure guideline for trichloroethylene and the 4-day average Freshwater Aquatic Life Criteria for copper.
7. Physical factors, and chemical and biochemical processes, which were not considered in the contaminant transport analyses, are expected to significantly reduce the concentrations and amounts of contaminants calculated to reach the Duwamish Waterway from the EMF site.

RECOMMENDATIONS

Additional monitoring is recommended to more accurately assess the extent and potential impact of ground water contamination. It is recommended that this monitoring proceed as outlined in the initial Soil and Ground Water Assessment Plan for Boeing EMF; that is:

"Water quality samples will be collected for a period of two years, with samples being taken quarterly for the first year. At the end of one year, an evaluation will be made and the sampling intervals adjusted accordingly."

The end-of-the-year evaluation should describe recommended remedial measures as appropriate.

SCL 05926

INTRODUCTION

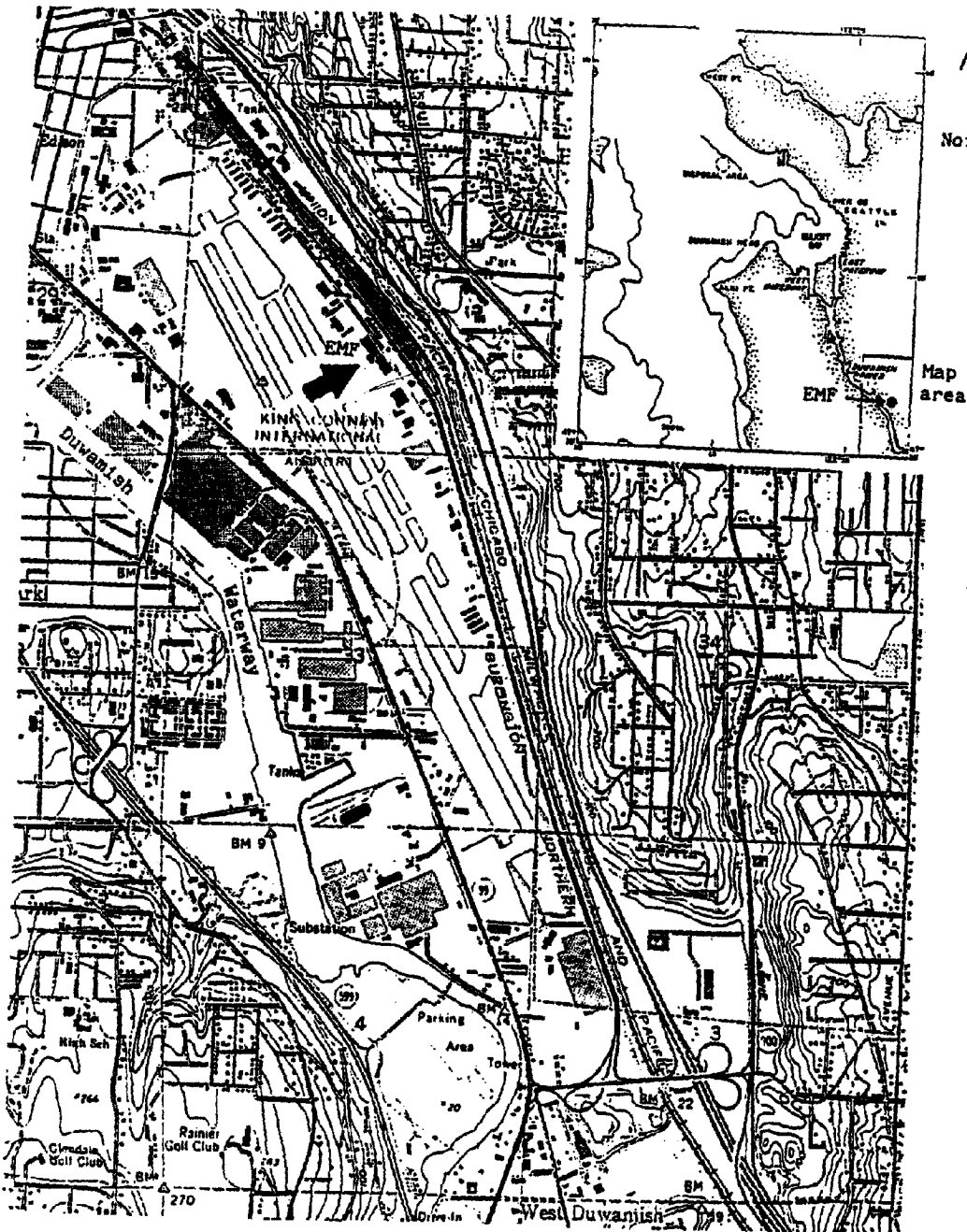
This report presents the initial results of an investigation to characterize ground water and soil contamination in the vicinity of The Boeing Company's Building 3-962, also known as the Electronic Manufacturing Facility (EMF). EMF is located at 7355 Airport Way South, adjacent to the east boundary of Boeing Field/King County International Airport in south Seattle, Washington (see Figure 1).

The investigation was conducted by Landau Associates, Inc. on behalf of Boeing Aerospace Company (Boeing) in response to a Washington State Department of Ecology (WDOE) Order No. DE 82-469, dated 7 October 1982, as amended by Order No. DE 82-469, First Amendment, dated 4 April 1985.

The specific scope and objectives of this investigation, as established in WDOE Order No. DE 82-469, are to:

- (1) Identify the direction of ground water flow and the detailed hydrogeology at EMF in sufficient detail to define all potential migration pathways of contaminants in the ground water and to select appropriate remedial alternatives.
- (2) Identify the concentration distributions of hexavalent chromium and trichloroethylene in the ground water.
- (3) Identify the presence of contaminants in the ground water other than hexavalent chromium and trichloroethylene.
- (4) Identify the locations, quantities, concentrations, and sources of hexavalent chromium and trichloroethylene (and other contaminants).
- (5) Describe onsite and offsite ground water uses and use rates.

SCL 05927



Reference: U.S.G.S. 7.5 Minute Series
(Topographic) Map: Seattle
South Quadrangle.

Scale
0 1/2 1 MI.

LANDAU ASSOCIATES

2

Vicinity Map-EMF

SCL 05928

Figure

CTY0050831

SEA291288

On 3 May 1985, Boeing submitted a list of tasks to be addressed under the pending Ground Water Assessment Program to WDOE for their review and approval. The tasks were designed to generate the data required to meet the program objectives. This submittal also contained an assessment of onsite and offsite ground water use, and thus responded to the fifth program objective cited above. The assessment of ground water use indicated that there were no registered onsite or offsite ground water production wells inside a 3-mile radius from EMF. Therefore, the Duwamish Waterway was established as the primary receptor of concern for contaminants in ground water.

On 21 June 1985, Boeing submitted a detailed Soil and Ground Water Assessment Plan to WDOE (The Boeing Company 1985). This plan contained the following specific tasks and approaches to complete the program objectives:

- o Location and installation techniques for additional monitoring wells
- o Soil and ground water sampling procedures
- o Chemical testing procedures
- o Analytical program to identify contaminants other than hexavalent chromium and trichloroethylene

Boeing submitted final amendments to the plan to WDOE on 28 August 1985. This plan reflected several refinements negotiated between Boeing and WDOE (number of monitoring wells, analytical approaches, etc.).

SCL 05929

This report is prepared in response to a provision in the amended plan that:

"An assessment report should be prepared immediately after the new wells are installed, water level elevations have been determined, and the first round of water quality results are completed."

Analysis in this report is based on one round of sample collection and testing. A second round of sampling is scheduled for April 1986.

A separate issue related to the leakage of chromic and waste acid from a failed pipe chase uncovered during construction of a new pedestrian entry way to EMP in November 1985 is discussed in Appendix F to this report.

BACKGROUND

From 1962 to 1982, a plating facility was in operation at EMP. Removal of the plating facility began in May 1982. During removal, a soil core sample was taken and chemically tested to determine if soil was contaminated in the vicinity of the plating operation. Evidence of chromium contamination was detected as a result of testing and reported to the EPA National Response Center and WDOE by Boeing on 20 May 1982. As part of the notification, Boeing informed EPA and WDOE that cleanup operations would be initiated.

On 16 August 1982, WDOE issued a Notice of Violation in response to "leakage of chromic-sulfuric acid into the ground water". Boeing responded to the notice in a letter dated 23 August 1982, outlining their intent to install well points and

SCL 05930

commence a pumping program to monitor and reduce concentrations of hexavalent chromium in ground water. Several well points were installed in September 1982. Initial concentrations of hexavalent chromium in the ground water were in the range of 0 to 8 parts per million (ppm).

WDOE issued an order (DE 82-469) on 7 October 1982, directing Boeing to: 1) remove and dispose of contaminated soil in accordance with Washington State Dangerous Waste Regulations (Chapter 173-303 WAC), and 2) pump and treat contaminated ground water to reduce hexavalent chromium to trivalent chromium if hexavalent chromium concentrations exceeded 6 ppm, or discharge ground water to the METRO sanitary sewer under permit if concentrations were less than 6 ppm. The order also specified that pumping be continued until hexavalent chromium concentrations in ground water stabilized at, or below, the EPA Drinking Water Standard of 0.05 ppm. Boeing commenced the pumping program on 22 October 1982. In addition, Boeing removed approximately 30 yards of contaminated soil from the site and disposed of it at an approved hazardous waste disposal site.

Evidence of trichloroethylene contamination was detected in the excavated area on 29 October 1982. Results of chemical testing indicated the presence of trichloroethylene in ground water samples in the range of 80 to 960 ppm. Following sample testing, WDOE directed Boeing to break out additional floor area and excavate an additional 6 yards of soil near the spill source. Chemical tests conducted on soil samples indicated that concentrations of hexavalent chromium did not exceed the State

SCL 05931

Dangerous Waste Standard of 5 ppm. In a 16 December 1982 telephone communication to Boeing, WDOE established the following contaminant concentration limits for ground water potentially influenced by EMF:

o Hexavalent chromium:

- Less than or equal to: 5 ppm for dangerous waste*
0.5 ppm for aquatic life
0.5 ppm for drinking water

o Trichloroethylene:

- Less than or equal to: 100 ppm for dangerous waste
45 ppm for aquatic life
0.0027 ppm for drinking water

During a 29 February 1983 meeting with WDOE representatives, Boeing reported that nearly 250,000 gallons of ground water had been pumped from areas near the spill source. Results of ground water analysis indicated that concentrations of hexavalent chromium and trichloroethylene were below the Freshwater Aquatic Life Criteria specified by the WDOE except for one location, where the concentration of trichloroethylene was 120 ppm.

In a letter dated 4 March 1983, WDOE gave Boeing permission to backfill excavated areas, repave the floor, reduce pumping activity, and continue monitoring ground water quality on a quarterly basis. WDOE directed Boeing to maintain four existing well points and to install one additional well point for future monitoring.

* Based on EP Toxicity

SCL 05932

Analysis of ground water samples collected in August and September 1983 indicated that concentrations of hexavalent chromium and trichloroethylene were increasing at a number of locations. Boeing continued to collect and analyze ground water samples on a quarterly basis.

Boeing completed backfilling and paving of the excavated area on 21 June 1984. On 27 November 1984, Boeing petitioned WDOE to issue a Notice of Satisfaction of Order in response to Boeing's contention that the EMF site was then in compliance with all requirements of WDOE Order DE 82-469. In their 6 March 1985 letter to Boeing, WDOE responded by stating that the ground water quality data submitted by Boeing was inconclusive and that:

"Without additional ground water pumping activities, there is no assurance that the ground water hexavalent chromium concentrations have stabilized at the lowest practical levels."

The letter also stated that a WDOE Final Cleanup Policy (effective date 10 July 1984):

"...defines cleanup levels for hexavalent chromium and trichloroethylene in ground water to be 0.05 ppm and 1.8 ppb (micrograms per liter), respectively. Those cleanup levels protect ground water as a potential drinking water source, and will be considered target cleanup levels for the Boeing EMF site."

In the letter, WDOE reported that they intended to amend the existing Order to reflect the target cleanup level and reissue the amended Order within 30 days. The amended Order was issued on 4 April 1985, resulting in the scope of soil and ground water investigations described in the Introduction to this report.

FIELD PROGRAM

A Soil and Ground Water Assessment Plan was developed by Boeing to establish procedures for conducting the sampling and testing program required by WDOE. The field program established in this plan had two major goals:

- o To identify the presence, character, extent, and mobility of contaminants in ground water at the EMF site, and
- o To determine if a pathway exists between contamination identified onsite and the Duwamish Waterway.

The field program consisted of the following:

- o Installing eight new monitoring wells at six locations (including multiple depth wells at two locations).
- o Collecting and testing ground water samples at eight new wells and five existing well points to characterize ground water quality and the nature, extent, and mobility of contaminants in ground water.
- o Monitoring ground water levels in wells at EMF to determine tidal influence on ground water.
- o Collecting soil samples during well installation to determine stratigraphy of underlying soil, the presence of the silt layer(s), and water-bearing zones.
- o Measuring ground water elevations in over 40 monitoring wells in the Duwamish River Valley to determine regional ground water gradients.
- o Conducting chemical tests of soil as required to characterize subsurface contamination.

- o Conducting rising head permeability tests at all new monitoring wells to determine soil permeabilities and infer preferred pathways for ground water movement.

The location of the five well points (WP 3, 8A, 9, 9A, and 10) and the eight new monitoring wells (EMF 1s, 1d, 2, 3s, 3d, 4, 5, and 6) are shown on Figure 2. The eight new wells were installed from 16 to 23 October 1985. During drilling, soil samples were collected from borings EMF 1 and EMF 3 for chemical analysis. Well points WP 3, 8A, 9, and 9A were developed on 25 November 1985; well point WP 10 and wells EMF 1s, 1d, 2, 3s, 3d, 4, 5, and 6 were developed on 6 and 7 December 1985. Air-lifting techniques were used to develop all well points and monitoring wells. Procedures for installing and developing the wells and as-built well construction details are presented in Appendix A.

Ground water sampling was conducted on 15, 17, and 18 December 1985. Ground water samples were collected from each well point and monitoring well. Ground water and soil sampling procedures used are described in Appendix B, and Quality Assurance and Quality Control procedures used in the field are described in Appendix C.

Continuous water level monitoring was conducted from 16 to 18 January 1986 and again from 7 to 14 February 1986 to measure the potential influence of tidal fluctuations in the Duwamish Waterway on ground water elevations at EMF. Water level monitoring was conducted in all monitoring wells outside Building 3-962, except for EMF 6 (for reasons discussed in the Water Level

Scale (approximate): 1"=200'

EMF PARKING

Airport Way

AIRFIELD

KING CO. ARRIVALS BLDG

EMF 3-962

Well Points
3, 9A, 9, 9A, 10

EMF 2

EMF 5

EMF 4

EMF 14, EMF 15

EMF 3a

EMF 3d

EMF 6

9 9A

8A 3

Detail of circled area

Scale 1" = 20'

Hallway

North

SCL 05936

Monitoring Section below) using pressure transducers and an electronic recorder.

Chemical testing of ground water samples was conducted to determine the concentrations of the following constituents, indicator parameters, and general water quality parameters:

Metals

Hexavalent Chromium
Total Chromium
Lead
Nickel
Copper
Zinc

Organic

Trichloroethylene
1,1,1-trichloroethane
1,2-trans-dichloroethylene
Cyanide

Indicator Parameters

pH
Specific Conductance

General Water Quality Parameters

Chloride
Manganese
Iron
Sodium

Soil samples were tested for the same chemical parameters as ground water. Chemical testing was conducted by Laucks Testing Laboratories, Inc. using EPA-approved testing methods. Quality Assurance and Quality Control procedures employed by Laucks Testing Laboratories, Inc. during chemical testing are described in Appendix C.

Rising head permeability tests were conducted at all well locations on 31 January and 3 February 1986 to estimate the hydraulic conductivity of the subsurface formations.

SITE DESCRIPTION

The EMF site comprises approximately 6 acres located immediately east of the Boeing Field/King County International Airport in south Seattle (see Figure 1). The site is located

SCL 05937

near the eastern side of the Duwamish River Valley, which is about 1.5 miles wide at this location. The EMF site is relatively flat, with an average elevation of approximately 20 feet above mean lower low water (MLLW). From the site, the land slopes gradually downward to the Duwamish Waterway to the west at an inclination of about 4.5 feet per mile.

The Duwamish Waterway is located approximately 3700 feet to the southwest of the EMF site at its closest point, about 4 river miles from its mouth at Elliott Bay. The Burlington Northern Railroad mainline is located about 200 yards to the east of the EMF site. The railroad runs north-south along the eastern side of the Duwamish River Valley. Immediately to the east of the railroad, the land rises steeply to the Interstate 5 right-of-way, which is cut into the east slope of the valley.

The site is dominated by the main EMF building (Building 3-962), which occupies approximately 30 percent of the site. Minor structures are located in the southeast portion of the site adjacent to the main building. Most of the external site areas are occupied by concrete or asphalt parking lots and internal roads.

Surrounding land uses include the King County International Airport to the west, Airport Way South and the Burlington Northern Railroad mainline to the east, and light industrial and aviation-related uses to the north and south oriented along Airport Way South.

SCL 05938

The potential for the buried Duwamish River channel to act as a preferred pathway for contaminants was not considered in the contaminant flux calculations. Permeabilities calculated for what was originally inferred to be portions of the buried channel (EMF 2, 5, and possibly 4) and permeabilities for the surrounding alluvium are very similar, indicating that the channel does not constitute a preferred pathway.

Contaminant flux calculations based on initial ground water test results demonstrate that potential contamination reaching the Duwamish Waterway from EMF would result in concentrations far below Freshwater Aquatic Life Criteria. Therefore, it was determined that additional ground water modeling and flux calculations for other contaminants was unnecessary.

FINDINGS AND CONCLUSIONS

The findings and conclusions below are based on field investigations and contaminant transport analyses conducted to date.

- o The location of the buried Duwamish River channel near the EMF site could not be determined with certainty. Chemical data indicate that the channel may be located near monitoring wells EMF 4 and 5.
- o The presence of several silt layers within the fill and alluvium have created localized semi-confined water-bearing zones. These layers act as partial barriers to contaminant migration toward the Duwamish Waterway; however, they are not extensive enough to completely retard the movement of the contaminants.

SCL 05939

- o Except for concentrations of trichloroethylene in well points WP 9 and 9A, all levels of organics in the ground water were below Freshwater Aquatic Life Criteria. The maximum level of trichloroethylene, 190,800 ppb in WP 9A, is approximately nine (9) times the maximum concentration allowed under the Freshwater Aquatic Life Criteria for chronic exposure.
- o Concentrations of hexavalent chromium were at or below detection limits in all monitoring wells and well points. This is due primarily to the chemical reduction of hexavalent chromium to trivalent chromium within the natural soil environment.
- o Elevated concentrations of trivalent chromium, copper, lead, and zinc were found in well points within the EMF building. The elevated concentrations may be attributed in part to the plating operations and the use of galvanized steel pipes as casing for the well points. The metal exceeding criteria by the highest ratio was copper, with a maximum concentration of 10,000 ppb in WP 9.
- o Conservative assumptions were made in calculating mass movement rates for trichloroethylene and copper from EMF to the Duwamish Waterway. Based on these calculations, maximum concentrations of trichloroethylene and copper in the Duwamish Waterway were determined to be 0.012 ppb and 0.0012 ppb, respectively. These calculated concentrations are well below the 21,900 ppb chronic exposure guideline for trichloroethylene and the 4-day average Freshwater Aquatic Life Criteria of 12 ppb for copper (see Table 2).

- o Physical factors, and chemical and biochemical processes, which were not considered in the contaminant transport analyses, are expected to significantly reduce the concentrations and amounts of contaminants calculated to reach the Duwamish Waterway from the EMF site.

RECOMMENDATIONS

The findings and conclusions of this report are based on a single ground water monitoring event. Additional monitoring is recommended to more accurately assess the extent and potential impact of ground water contamination. It is recommended that this monitoring proceed as outlined in the initial Soil and Ground Water Assessment Plan for Boeing EMF; that is:

"Water quality samples will be collected for a period of two years, with samples being taken quarterly for the first year. At the end of one year, an evaluation will be made and the sampling intervals adjusted accordingly."

Sampling will be conducted at all wells outside of the EMF building and at well point WP 10 located inside the building, as proposed in the initial plan. These wells are located such that the downgradient migration of the contaminant plume(s) may be monitored and any potential migration through the buried channel detected. Because of recent construction activities within EMF, well points WP 3, 8A, 9, and 9A are no longer accessible for monitoring.

SCL 05941

Ground water samples will be chemically tested for the same parameters as the initial testing described herein, excluding cyanide, which was below detection limits at all wells and well points, and including vinyl chloride, a breakdown product of trichloroethylene and 1,2-trans-dichloroethylene.

Ground water levels will be measured quarterly during each sampling to better understand the ground water flow system(s) at EMF. Ground water levels will also be measured at three additional times throughout the year in order to obtain ground water level trends over the entire year. Trends for each well will be compared to determine:

- o Interconnections between the water table aquifer and the deeper semi-confined water-bearing zones.
- o Water level fluctuations in monitoring wells EMF 3d and 5 relative to the other wells.
- o Possible effects of leaky pipes, site drainage, and other factors on ground water levels.

At the end of the first year of monitoring, an assessment report will be prepared. This report will include results of all chemical testing, results of continued ground water level monitoring, and changes and/or refinements to this report's

SCL 05942

conclusions and recommendations based on the continued monitoring program. If required, the assessment report will also include an evaluation of appropriate remedial actions for the site.



Respectfully submitted,

LANDAU ASSOCIATES, INC.

By:

Henry G. Landau

Henry G. Landau, Ph.D., P.E.

and

Elizabeth C. Doan

Elizabeth C. Doan

HGL-ECD/sg
No. 25-05
11 April 1986

SCL 05943